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Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

MINUTE AMOUNTS OF CHEMICAL ELEMENTS IN RELATION TO PLANT GROWTH.*

DURING the past few years there has been a reawakened interest in the so-called minor elements and their effect on the growth and development of plants and animals, and their relation to malnutrition and disease. This renewed interest may be attributed to the notable advances that have been made since 1920 in our scientific knowledge of plant and animal nutrition, for many of these advances have been made possible only because of the recognition and experimental control of organic and inorganic substances in micro-quantities. Actually, as early as 1869, some researches were carried out on manganese and zinc, and their effects on plants were fairly well worked out, but the significance of the investigations was overlooked and for a long period the standard teaching still held that only ten chemical elements (nitrogen, phosphorus, sulphur, calcium, magnesium, potassium, iron, carbon, hydrogen and oxygen) were generally indispensable for the growth of higher plants. Many other chemical substances, if found to be effective at all, were regarded merely as plant stimulants or poisons. In 1914, the requirement for normal growth of maize plants of chemical elements not included in the list of ten was demonstrated by controlled water-culture experiments, but scant attention was paid to these investigations until much later, nor did appreciation immediately follow of the significant discovery, in 1923, that boron played an essential rôle in the growth of the broad bean and several other plants. It is therefore only comparatively recently that the relation of certain minor elements to some of the physiological "diseases" of plants has been definitely recognised, although research on this subject began many years ago.

The investigator of the nutrition of higher plants such as are able to grow in solutions of purely mineral character, has the advantage of a technique not available to the investigator of animal nutrition. An appreciation of this advantage, coupled with a growing recognition of the important part played by the minor elements in plant nutrition, has led to extensive investigations and, in recent years, many important discoveries have been made. In 1923, it was shown that manganese was an indispensable

*This article is based on a paper by D. R. Hoagland (*Science*, Vol. 91, No. 2372, pp. 557-560, 1940).

component of a satisfactory nutrient solution. Later, during the period 1926–1931, certain experiments conducted with the use of highly refined technique led definitely to the conclusion that the varied species of plants studied could not complete their cycle, or indeed might show complete growth failure, in the absence of minute but determinable quantities of boron, copper and zinc, as well as manganese. More recently, evidence has been adduced in support of the view that molybdenum is also one of the elements indispensable to higher plants. This does not complete the list of essential elements ; there are, for example, indications that others should be added, but the evidence is not yet conclusive for complete indispensability for a wide range of plant species.

The term "minor" or "accessory", as applied to the chemical elements required in minute quantity, is somewhat misleading. These elements are as essential for growth as nitrogen, phosphorus and potassium, and the term "micro-nutrient elements" is much to be preferred. Although the effective amounts of the elements in question are not quite so exceedingly small as those involved in plant responses to certain vitamins and hormones, nevertheless extremely low concentrations produce visible effects.

Boron, manganese, copper and zinc are now generally accepted as essential elements, and the technique for growing plants under controlled conditions has advanced sufficiently to permit quantitative studies to be made on the effects of successive minute increments of these elements. To prove decisively the indispensability of such elements for varied species of plants with different quantitative requirements, the utmost care must be taken in the refinement of methods of water or sand culture. At one time the question arose as to whether, in ordinary experiments in plant nutrition and especially in agricultural practice under natural soil conditions, the investigator need be concerned with elements like boron, copper, manganese and zinc. This question can now be answered definitely. In the experiments of the plant physiologist, conducted without special attention to these elements, their presence in adequate amounts depends on accidental factors such as choice of chemical materials, distilled water or culture vessels, which yield uncontrolled contributions of micro-nutrients. Earlier investigations on the effects of different nutrient solutions on plant growth will therefore need re-examination in the light of this consideration.

Hundreds of reports published during the past few years in many parts of the world show that, under certain field conditions, crop plants may fail to make normal growth, or may become diseased, through deficiency of boron, copper, manganese or zinc. Especially numerous are instances of boron deficiency to which commercially important diseases of the sugar beet, celery, apple, alfalfa and many other crop plants are attributed. Frequently such boron deficiencies have been corrected economically by application to the soil of boron-containing compounds. It should be borne in mind however that those elements essential for plants in minute amounts may also become toxic at concentrations in the nutrient medium which are still very small. The physiological range is sometimes relatively narrow, so that, in many cases, extremely small increases in one or more of these essential elements, over and above the small quantity required by the plant, are definitely harmful. As an example, some irrigation waters may add to the soil sufficient boron to cause severe injury to sensitive crops ; this has raised an imporant economic question in some areas.

As another illustration of deficiency causing plant disease, it has been shown that previously obscure nutritional disorders of fruit trees, such as "little leaf", "mottle leaf" and "rosette", are the results of a deficiency of zinc, minute as the requirement is. It was at first difficult to believe that a simple zinc deficiency was involved for, to cite a specific case, a peach orchard was found to be diseased although growing in soil containing within the root zone a total of approximately 3,000 pounds of zinc per acre, of which the trees, at seven years of age, had removed only about one half-pound. Nevertheless, controlled experiments by water-culture technique, and other evidence, proved that zinc deficiency was indeed the cause of the disease. This naturally raises the difficult question as to what factors govern the availability to plants of zinc in the soil. Some experiments suggest that, at least in certain soils, this availability may have a relation to the growth of soil micro-organisms which may themselves absorb zinc.

There is another type of "disease" that may affect fruit trees in the field, caused by deficiency of copper. Here also similar symptoms have been reproduced in plants growing in culture solutions lacking only copper. Manganese deficiencies for various kinds of plants under field conditions are also well known, and can be reproduced under controlled conditions.

These are only illustrations of the significance to agriculture of chemical elements effective in minute amounts. It should be emphasized that not all soils are deficient in the ability to supply these elements to the plant. Furthermore, when a deficiency exists, it does not necessarily follow that it will be corrected by the use of some fertilizer containing minute amounts of the element in question as an impurity. The chemical fixing ability of the soil enters as a most important factor. In practice, deficiencies sometimes have to be corrected by direct application to the plant of the deficient element by spraying, by injection, or by some other means.

Research on the micro-nutrient elements has been followed rapidly by practical applications, but this research is still inadequate in that our

knowledge of the functions of mineral micro-nutrients in plant metabolism is extremely limited. A deficiency of boron exerts profound effects in the meristematic regions of the plant, yet there is apparently no really satisfactory hypothesis concerning chemical reactions in the plant in which boron might assume an indispensable rôle, a rôle which appears to be specific to boron, as very extensive experiments with other chemical elements have demonstrated.

Outstandingly important advances have been made in general research on oxidation-reduction systems in living organisms and these may lead to an understanding of the functions of the mineral micro-nutrients. Thus, the oxidation of carbohydrates involves intricate enzyme systems in which hydrogen carriers have a place, and it is possible that such oxidations are catalyzed by metals outside the cells. Recently copper has been reported as an essential component of certain oxidase systems which are of importance in plants, and there is evidence that manganese is essential to respiration and nitrate reduction in the plant. It is also possible that a zinc protein enzyme catalyzes the splitting of carbonic acid to water and carbon dioxide. A secondary effect of zinc deficiency on the content of auxin growth substance in the plant has also been observed, the zinc-deficient plants showing much less auxin activity than those having an adequate supply of zinc. In general there appears to be ample justification for the assumption that minute amounts of inorganic elements and minute amounts of organic substances may frequently be inter-associated in their actions. It should therefore be feasible to study some of the possible relations of micro-nutrient elements to the synthesis of vitamins or their precursors by the plant.

Deficiencies in essential metallic elements commonly produce chloroses of various types in green plants, but quite apart from such marked failures of chlorophyll synthesis, the essential elements may also have an effect on photosynthetic efficiency. This has not yet been proved, but the results of recent studies on *Chlorella,* undertaken with a view to investigating factors influencing the efficiency of photosynthesis, are highly promising. By the technique adopted in these experiments, it was found that the utilization by *Chlorella* of certain combinations of micro-nutrient elements coincided with increased light-absorbing ability on the part of the plant. Whatever the final interpretation of these experiments may be, the general question is of great interest as to what concentrations and relations of metals in the green cell are conducive to the largest synthesis of sugar permitted by other factors in the environment.

Workers in animal and plant nutrition are finding common interests in their researches on minute factors in cell metabolism, especially since it has been recognised that certain animal deficiency "diseases" may be traced to lack of micro-nutrient elements in crops and soils. Investigators are now seeking to discover how the environmental factors influencing the composition of the plant are related to its value as a food for animals ; in other words, how do climate, soil and manure affect nutritional quality? An interesting example of a differential requirement for plant and animal is that of the cobalt-deficiency disease of sheep and cattle which has been extensively studied in New Zealand and Australia. The cobalt deficiency in certain soils did not diminish the growth of pasture plants, but the animals suffered from lack of cobalt in the ration. Apparently, deficiency of copper for the needs of animal nutrition may also occur in various regions, while manganese deficiency certainly requires further study.

There exists, on the other hand, the possibility that the plant might absorb special mineral components of the soil in such amounts as to produce a toxic foodstuff. Some species of plants growing in selenium-containing soils absorb so much of this element that the plant becomes severely toxic to the animal. It is an interesting aspect of plant physiology that ability to accumulate selenium from the same soil varies strikingly among different species of plants. Plants may also absorb fluorine, arsenic and other toxic elements when naturally present in, or added to, the soil.

The extensive literature that has grown up around the subject of micro-nutrient elements well illustrates the remarkable number of investigations that have been carried out since the important part played by these elements was first appreciated. A bibliography of the subject, compiled in 1935 and 1936, revealed about 3,000 references to some 30 minor elements which were classified into those known to be essential to plants, those unessential, and those that are doubtful. The investigation of soil and plant interrelations and its bearing on problems of animal nutrition is so difficult that lengthy and patient co-operative research on the part of plant and animal physiologists, soil chemists, and plant breeders will be needed completely to elucidate them.

EFFECT OF SHADE AND MANURE.

The effect of shade on tea quality is at present undetermined and deserves serious research. J. G. de Gens in an article in *Bergcultures*, 1939, 13 : 1474-85, points out that the shade tree has other uses besides providing shade ; its roots break up the pan and so enable the tea roots to penetrate deep, while the foliage provides a green manure. On the whole the tendency among planters seems to be to expose the green parts of the plant to full light, while protecting the roots with some low-growing shade plant which can be cut and used as a green manure. After reviewing some of the work done abroad on the influence of manure on quality, the author concludes that while manuring benefits the tea as regards its vegetative processes it has no direct effect on the quality of made tea.

THE DEGREE OF CROSS POLLINATION IN CACAO IN NIGERIA.

By O. J. Voelcker.
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Where cacao seed of known parentage is required, it is desirable in the first place to have some idea of the degree of cross pollination occurring under natural conditions. For example, the Nigerian Department of Agriculture has based its cacao programme on the need for having available tested seed for distribution to farmers; to enable the Department to do so, clonal blocks of the selections have been established. When the self-fertilized progeny of these selections have been proved, it will then be possible at once to distribute seed in quantity from the clonal blocks of the best selections.

Actually these clonal blocks have been planted so that each group of budded trees is adjacent one to the other and no attempt has been made to isolate them. If cross pollination takes place to any large extent, it would be unsafe to use naturally pollinated seed from any particular clonal block, since such seed might well have been crossed by neighbouring—and probably inferior—trees.

In Trinidad, Voelcker (1) showed that a high degree of cross pollination took place ranging from approximately 50 per cent. on self compatible trees to nearly 100 per cent. on self incompatible trees. Voelcker did not, however, indicate the distance over which pollen might be carried from one tree to another.

The method of axil spot determination discovered and used by Harland and Frecheville (2) in assessing the degree of cross pollination was employed in examining the pod progenies of three trees at Moor Plantation, Ibadan.

Experimental Material.

Two yellow pod trees were chosen in a block of Forastero cacao which had been planted in 1912 with seed from red pods. These two, trees No. 446 and No. 691, were chosen because they were found to be surrounded in the main by trees carrying red pods. Another yellow pod tree, No. 57, was selected from a similar block of cacao planted with seed from yellow pods. The immediate neighbours of this tree were yellow pod types with the exception of tree No. 56 which had red pods. Figures I, II and III show diagrammatically the position of these trees in relation to their neighbours. It was unfortunate that both blocks of cacao were uneven, and that gaps occurred which have only recently been filled with seedlings.

It will be remembered that Harland and Frecheville (*loc. cit.*) proved that a yellow pod cacao tree on self fertilization produced only progenies with no axil spot. Pod progenies of such trees showing even one seedling with axil spot must have been fertilized by pollen brought in from another tree.

Examination of Naturally Pollinated Progenies of Trees Nos. 446, 691 and 57.

During the 1938-39 season, all pods from these three trees were harvested and the beans from each pod were sown separately. Examination for the presence or absence of axil spot took place when the seedlings were about four weeks old. The results were as follows:—

Table I.

Yellow Pod Tree No.	Pod Progenies without Axil Spot.	Pod Progenies with Axil Spot.
446	86	15
691	56	9
57	72	3

The proportion of seedlings with and without spot in the pod progenies with axil spot were as follows:—

Table II.

Tree No. 446.		Tree No. 691.		Tree No. 57.	
Examination of 15 Pods.		Examination of 9 Pods.		Examination of 3 Pods.	
Seedlings.		Seedlings.		Seedlings.	
With Spot.	Without Spot.	With Spot.	Without Spot.	With Spot.	Without Spot.
17	16	11	29	19	23
2	34	21	20	10	25
12	26	1	41	6	31
8	11	20	20		
1	16	15	21		
12	11	17	13		
11	24	3	43		
7	28	14	19		
1	34	7	40		
1	37				
17	15				
13	29				
21	22				
36	2				
7	25				

Examination of Control-pollinated Progenies of the Three Trees.

In 1939 several flowers on each of the three trees were self-fertilized, others were crossed with pollen from certain directly adjacent trees.

FIGURE I.—POSITION OF YELLOW POD TREE No. 446

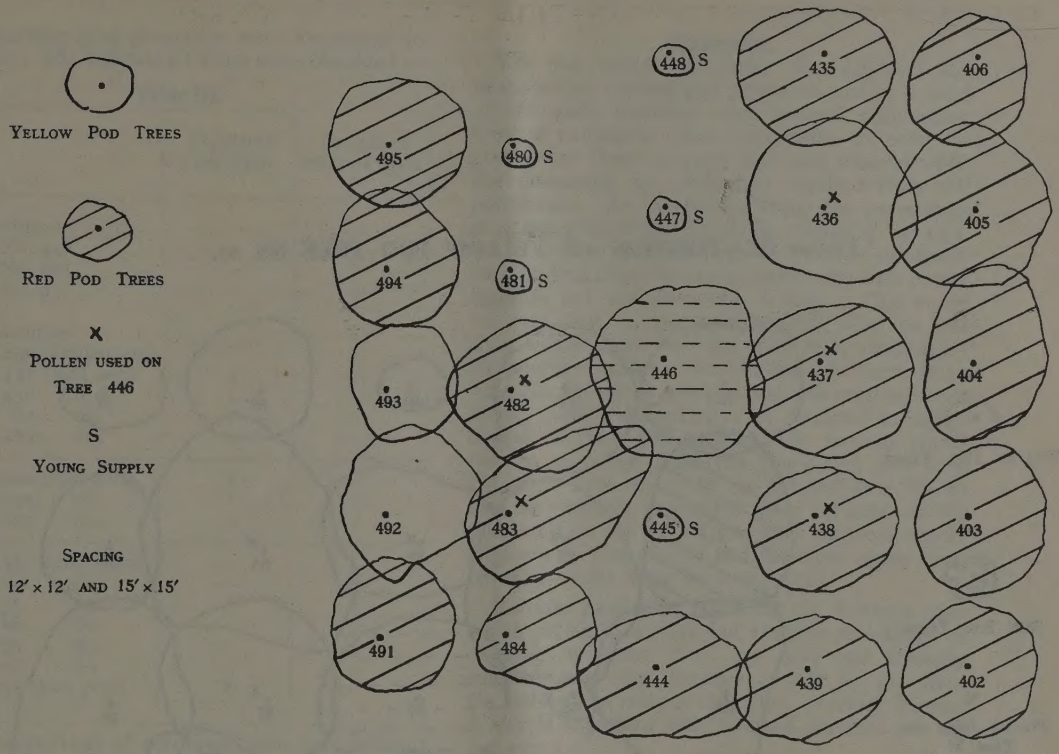


FIGURE II.—POSITION OF YELLOW POD TREE No. 691.

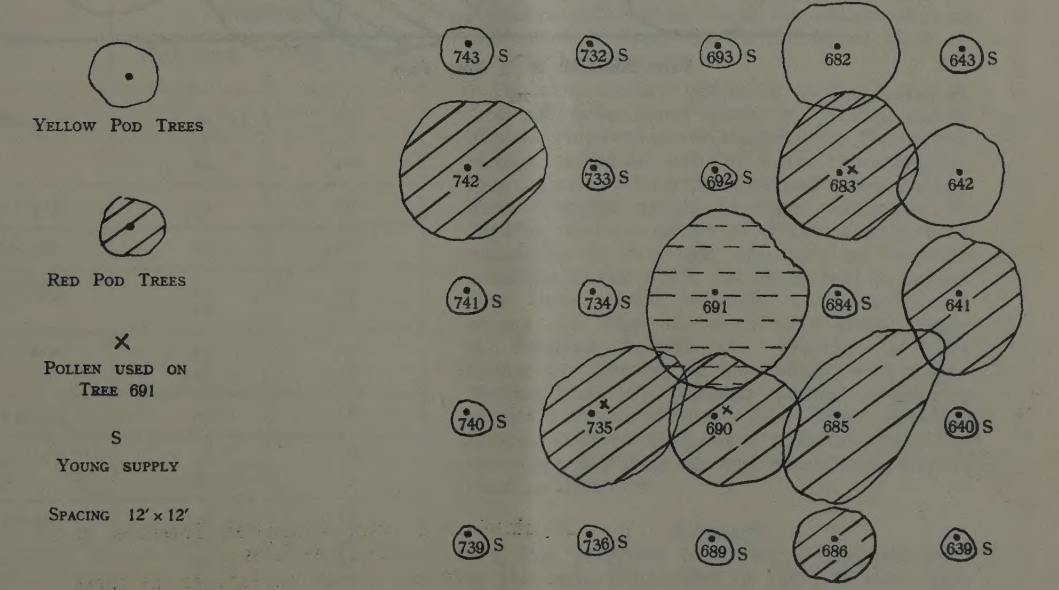
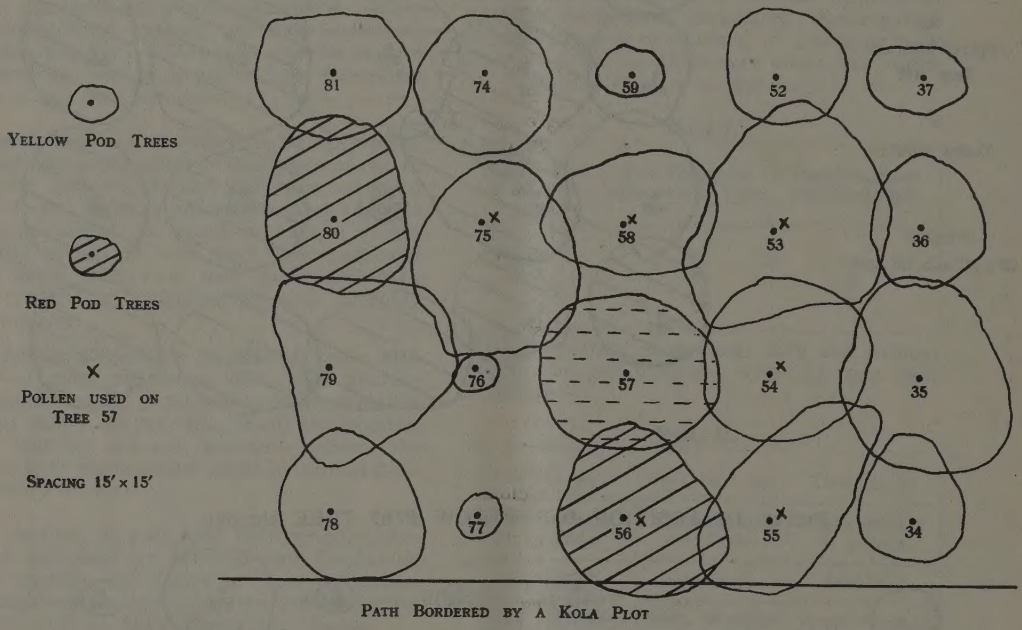


FIGURE III.—POSITION OF YELLOW POD TREE No. 57.



The resulting pod progenies were examined for axil spot. The following results were obtained:—

Table III.

	Progenies with Spot.	Progenies without Spot.
el -fertilized		
Tree No. 446	—	2
T ee No. 691	—	1
Tree No. 57	—	8
Cross-fertilized		
46×436 (Yellow pod)	—	2
446×437 (Red pod)	3	—
446×438 do.	1	—
446× 82 do.	1	—
446×483 do.	2	—
691×690 (Red pod)	2	—
691×735 do.	1	—
691×683 do.	2	—
57×53 (Yellow pod)	—	4
57×54 do.	—	5
57×55 do.	—	3
57×58 do.	—	3
57×75 do.	—	3
57×78 do.	—	2
57×56 (Red pod)	6	—

The proportion of seedlings with and without spot from these crosses, the pod progeny of which were recorded as having spot present, were as follows:—

Table IV.

Cross.	Seedlings.	
	With Spot.	Without Spot.
446×437	12	22
	18	20
	12	16
446×438	5	16
446×482	20	16
446×483	10	19
	16	18
691×690	23	21
	21	27
691×735	25	18
691×683	31	6
	30	3
57×56	14	15
	12	16
	19	21
	20	18
	8	16
	12	27

Discussion.

The two yellow pod trees Nos. 446 and 691 produced 24 crossed pod progenies out of a total of 166 pods resulting from natural pollination. Control pollination was undertaken in order to prove that these 24 pods had been crossed while the remaining 142 pods had resulted from self pollination. As the figures stand the percentage of cross pollination occurring naturally is 14.4, but it will be realized that the number of stands surrounding these two trees, filled only with young supplies not yet flowering, is large. This would indicate that 14 per cent. crossing may be less than would occur were the trees fully surrounded by mature cacao. The results obtained from Tree No. 57, which was growing in a more uniform block, tend substantially to confirm a higher degree of cross pollination. The natural transference of pollen from the single red pod Tree No. 56 to Tree No. 57 (if the red pod Tree No. 80 can be omitted) accounted for 4 per cent. of the pods on Tree No. 57. There were six trees closely adjacent to Tree No. 57 and therefore 24 per cent. crossing might have been expected.

No data have been given for the distance over which pollen is carried, but the low percentage of crossing in Trees Nos. 446 and 691 strongly suggests that the distance cannot be far since the bulk of the trees in that plot, of which Figures I and II represent only a small portion, are red pod types.

Until further information comes to hand, it can be assumed that any tree in the outside row of a clonal block will yield about 15 per cent. of pods crossed by pollen from an immediately adjacent plot, and that the use of one guard row should be sufficient to reduce the amount of cross pollination by trees outside the clonal block to a negligible quantity.

The very marked difference in the degree of cross pollination found to exist in Trinidad and in Nigeria is interesting and suggests that the vectors of cacao pollen are different in the two countries. It is the writer's view that ants and aphids are the most probable agents of cross pollination in Nigeria, while a species of thrips may be held responsible in Trinidad. No facts are however available on this point. It might well be argued that there should be more cross pollination among the Nigerian trees than among those in Trinidad because the branches of the former are allowed to intermingle with neighbouring trees. In Trinidad annual pruning is carried out to prevent this. Thus crawling insects, such as ants, have a better chance of carrying pollen from one tree to another in Nigeria than in Trinidad.

Summary.

1. Pod progenies from two yellow pod trees in the main surrounded by red pod trees were examined for axil spot. A total of 166 naturally pollinated pods yielded 24 progenies with axil spot.

2. Seventy-five pod progenies from one yellow pod tree surrounded by trees with yellow pods, except for one tree which had red pods, gave only three in which axil spot was present.

3. Control pollination was undertaken to confirm the supposition that progenies with axil spot were the result of cross pollination.

4. As a result of the data obtained, it is assumed that about 25 per cent. of the pods on any Nigerian cacao tree are produced as a result of cross pollination provided that tree is uniformly surrounded by others.

5. It is further concluded that the distance over which pollen is carried is small, and that it is unlikely to extend beyond immediate neighbouring trees.

Acknowledgments.

The writer wishes to express his thanks to Messrs E. J. Spiff and S. A. Amole, African Technical Assistants. These Assistants were responsible for all the control pollinations, and in the absence of the writer, for axil spot determinations. The writer is also indebted to Capt. J. R. Mackie, Director of Agriculture, for permission to publish this paper.

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1. Voelcker, O. J.—The Incidence of Cross-pollination in Cacao. *Seventh Annual Report on Cacao Research* (1937), 1938.

2. Harland, S. C. and Frecheville, G. E.—Natural Crossing and the Genetics of Axil Spot in Cacao. *Genetica*, 9 (1927), 279-88.

FIXATION OF POTASSIUM IN SOILS.*

It has been shown that, when a mixture of soil and water containing a potassium salt was evaporated to dryness at room temperature, some of the potash became fixed in non-exchangeable form, the proportion fixed being increased by alternate wetting and drying at 70°, but no fixation occurred when the moisture content was maintained near the optimum for plant growth. As a result of mineralogical and X-ray analyses, it has been concluded that potash salts added as fertilizer were fixed in the soil in the form of muscovite, by reaction with colloidal silicates. Other experiments indicated that artificial phosphatic complexes of iron, aluminium, calcium, and magnesium, as well as phosphate-poor montmorillonites and similar materials, were able to fix potassium. The high potash-fixing capacity of the B-horizons of podzolic soils was attributed to the leaching down of montmorillonitic minerals which, it is inferred, form most readily under the climatic conditions of the podzol zone. A high potash-fixing capacity has also been observed in bentonite clay. Potassium fixation was accompanied by a decrease in the exchange capacity of the mineral equivalent to the amount of potassium fixed. It has therefore been assumed that the potassium ions first take up positions as exchangeable ions in the crystal lattice before they are fixed, and that only clay colloids having certain definite lattice structures can fix potassium. Heating to 500° destroys the fixing capacity of both montmorillonite and soil, presumably by destroying the lattice structure. Fixation of potassium in non-exchangeable form increases with the degree of calcium saturation in mineral soils, whereas organic soils, whatever their state of saturation, have a low fixing capacity. Alternate wetting and drying of soil increases, and addition of organic matter decreases, fixation of added potash.

Except for isolated samples, no pure minerals have been found to exhibit an appreciable fixing dower for potassium. Treatment of clay minerals with sodium carbonate increased, and removal of free alumina from clays decreased, fixing power, and it is suggested that free alumina is directly involved in the fixing process. In studies on the fate of potash fertilisers added to greenhouse soils, the amount of potassium fixed varied greatly from month to month, indicating that the properties of the soil that affect fixation are dynamic and possibly partly microbiological in nature.

The reverse phenomenon of release of potash from non-exchangeable to exchangeable forms has also been studied. It has been concluded that fixation and liberation were the result of the same equilibrium reaction which tended to prevent the maintenance of so high a level of exchangeable potash as to be subject to luxury consumption by the plant or to excessive losses by leaching. Neubauer tests support the view that non-exchangeable potassium may also be absorbable by plants, particularly in the form of mica. Exchangeable potassium is, however, exhausted before the non-exchangeable form is taken up. The removal of potash by crops from unmanured soils corresponds with the decrease in Neubauer value for potash. Plants show the usual symptoms of potash deficiency when the Neubauer value has been reduced to zero, but they can still extract potash from the soil. A direct relationship between soil texture and available potash content has been observed, heavy soils containing the most potash. Isotope measurements have been suggested as a method for studying potash forms in soils and rocks. A soil in which the potash has been largely replaced through base exchange should have a low isotope ratio. An approximate and rapid method for determining available potash has been described, depending on the colour produced by treating a specially-prepared soil extract with bismuth hyposulphite.

* Copied from *Reports of the Progress of Applied Chemistry*, Society of Chemical Industry, England, Vol. XXIV, 1939; Section on "Soils and Fertilizers" by G. V. Jacks. The references to literature have been omitted.

LAND MOVEMENTS

Their Classification and Relationships to Soil Erosion.

By F. Hardy.
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The fact that soil erosion represents merely one aspect of the general phenomenon of land denudation, involving mass-movement of rock and soil, is seldom stressed in text-books, nor is sufficient consideration given to land movement in the teaching of general geology. The literature of the subject, though vast, is scattered and inaccessible to most students, so that the publication of a comprehensive treatise*, summarising and co-ordinating detailed observations and records in this wide field, is particularly welcome at a time when soil conservation is receiving increasing attention from agriculturists. The book from which the following account is taken was written in 1937, after many years of study, by a specialist in geomorphology now a member of the staff of the U.S. Soil Conservation Service. A new classification of land movements is therein presented which reveals their relationships to climate and to geomorphic cycles.

Factors Employed in Classifying Land Movements.

Four chief factors are used in the scheme of classification; they are:—

1. *Kind of Movement.* —flowage *vs.* slippage.
2. *Rate of Movement.*—slow *vs.* rapid.
3. *Kind of Material.*—structure and mechanical composition of rock and soil.
4. *Water Content.*

An essential difference distinguishes the flowing of materials down slopes from their sliding or slipping; in sliding a *slip-plane* develops, separating the moving material from its bed. The rate of movement in either case depends on the angle of slope of the ground and on the internal and external friction to which the moving material is subjected. Friction is largely controlled by water content. In excess, water imparts free flow and permits rapid transportation, while in lesser quantities, it provides lubrication and permits only plastic flow or encourages the development and operation of slip-planes. The nature of the material that moves ranges from great blocks of rock to tiny particles of fine silt and clay; from masses many tons in weight to small driblets or surface smears.

Types of Land Movements.

The following types of movement have been differentiated on the basis of the above system of classification.

(A) Flowing Movements.—Land-creep.
  (I) Slow.—(1) soil-creep; (2) talus-creep; (3) rock-creep; (4) solifluction.
  (II) Rapid.—(5) earthflow; (6) mudflow; (7) débris-avalanche.

(B) Sliding Movements.—Landslide or Landslip.
  (8) slump; (9) débris-slide; (10) débris-fall; (11) rock-slide; (12) rock-fall.

(C) Subsiding Movements.

Description of Types of Land Movement.

(A) Flowing Movements.—Land-creep.

(1) Soil-creep.—*Slow downslope movement of soil, imperceptible except to long-continued observation.*

This is distinctly a surface phenomenon, affecting only the uppermost few feet of the land. The moving layer may carry with it the overlying vegetation as well as man-made structures. It is agriculturally important in that, when accelerated by deforestation which increases natural run-off and so deepens stream channels, surface soil may rapidly be lost. Evidences of soil-creep may be seen in curved tree-trunks, tilted telegraph poles and fence posts, broken walls, disalignment of roads and railway lines and accumulation of bands of stones below the soil surface.

The rate of creep depends on the angle of slope, the climate and the kind of soil, being most pronounced in loosely-consolidated material containing a wide assortment of rounded particles of different sizes. The occurrence of "*stone-lines*", as often seen in road banks, sections and soil profiles, was a puzzling phenomenon until it was explained as a result of differential creeping of the soil layers, whereby resistant rock fragments gradually work their way downwards to the zone of no movement.

Subsurface soil-creep may apparently proceed beneath a tough grass-sod; it may even occur on forested slopes, the finer soil particles passing through the root network, the larger being retarded. This action may encourage surface rooting, few roots being able to penetrate through the moving underlayer.

Various factors account for soil-creep; they include contraction and expansion of the surface humic soil through alternate drying and wetting; organic decay; removal of fine soil by rain-wash; freezing and thawing, and any mechanical process that loosens the soil so as to permit the downward motion of the free particles under the influence of gravity.

(2) Talus-Creep.—*Slow downslope movement of a talus or scree, consisting of coarse rock-waste.*

This is the same as soil-creep, except that the material consists of coarser particles up to irregular blocks several inches or feet in diameter. The natural angle of slope of a talus or scree is

* *Landslides and Related Phenomena.*—A Study of Mass-Movements of Soil and Rock, by C. F. Stewart Sharpe (Soil Conservation Service, U.S.D.A.); 1938, New York, *Columbia Univ. Press*, pp. 137. Price 15 shillings.

partly determined by the shape and size of its component particles; its maximum varies between 36 and 26 degrees. Talus-creep is most rapid in cold regions where interstitial water alternately freezes and thaws, causing expansion and contraction. In warm regions, it proceeds similarly through alternate heating and cooling. Running water may accelerate creeping, and growing plants and mineral decomposition may help by causing the disintegration of the rock fragments.

(3) ROCK-CREEP.—*Slow downhill movement of joint-blocks which have become detached from the bed-rock.*

The main agents in rock-creep are frost and growing plants whose roots pry off blocks of rock from the main mass. Detachment and movement here are favoured by interbedded thin clay strata or surface layers of clay.

(4) SOLIFLUCTION.—*Slow downslope flowing of soil or rock-waste saturated with water, derived usually from melting snow or continuous rain.*

(Deposits known in England as "head", "rubble-drift", "coombe", "warp" and "trail" probably originate from solifluction.)

Solifluction may take place in any climate, but only at the low temperatures of high altitudes, or above the timber line, is the process sufficiently intense as to allow full development of its characteristic landforms. The chief factors favouring solifluction are (*a*) absence of vegetation, (*b*) a continuous supply of water, such as is provided by melting snow, and (*c*) deeply-frozen soil or other condition producing impeded drainage of ground-water. The material carried is usually fine-grained, though large included blocks of rock may also be transported. Solifluction may occur on slopes as low as two or three degrees. It is much slower and more continuous than *mudflow*, and is not confined to one channel, but may affect a whole slope. Partly as a result of solifluction, blocks of rock or large stones may be brought to the surface by the flow of finer material around them, or moved slightly so as to form parallel rows, thus producing *block-fields*, *stone-fields* and *stone-stripes*.

(5) EARTHFLOW. — *Fairly slow downslope movement of soil or rock-waste on gentle slopes; the material moved may comprise whole sections of a land surface.*

This is the slowest of the three more rapid flowing movements. Its relatively low rate of flow is generally accounted for by small angles of slope around five degrees. Earthflow is favoured by somewhat peculiar conditions; for example, the occurrence of a porous stratum overlying an impervious slippery clay stratum or hardpan or bed-rock, or the super-position of a fissured clay layer on a porous fine-grained material, so that rain water may run through the clay and lubricate the sand surface below. The clay becomes super-saturated, and a slight shearing which may result, loosens the mass and causes it to move freely over the wet sand-bed. Earthflows frequently exhibit a slump at the head and a crevassed dump at the toe. They may affect very large areas; the bulky transported material sometimes causes serious river diversion.

(6) MUDFLOW.—*Relatively rapid downslope movement of masses of heterogeneous debris; it usually follows an existing river channel.*

This type differs from earthflow in that it moves more rapidly because of steeper gradient and greater water content. Mudflows usually occupy former water-courses, and commonly recur in the same channel. They develop when sufficient water is suddenly applied to an area where a suitable load of earthy material is readily available. They are often accompanied by small slumps and landslides along their margins, as along any stream.

The conditions favouring mudflow are (*a*) an abundant but intermittent water supply, (*b*) absence of vegetation, (*c*) unconsolidated or deeply-weathered, slippery clayey or silty material, and (*d*) moderately steep slope. Large blocks of rock may be transported in a mudflow and so carried and dumped many miles away from a mountain front. The transported material is unstratified and much mingled; it often contains numerous boulders, and it may spread fan-wise at its terminus like an alluvial cone.

Several subtypes of mudflow have been recognised, for example, *mudspate* of semi-arid countries, *alpine mudflow* caused by melting snow, *volcanic mudflow* affecting fine-grained volcanic ash or sand, and *peat mudflow* emanating from bursted bogs.*

(7) DEBRIS-AVALANCHE.— *Very rapid downslope movement of water-saturated soil and rock-waste on steep slopes.*

This resembles a rapid kind of mudflow such as may be caused by torrential rains in semi-arid countries. It also occurs frequently in humid regions on steep hillslopes, even when the land carries a dense covering of vegetation. Abundance of water is one of the chief causative factors; were the water content less the same material would move as a *debris-slide*. The typical débris-avalanche moves in a long and relatively narrow track; it is almost invariably preceded by heavy rains which increase the weight of the unstable material, as well as aid in its lubrication by reducing internal friction. Initial movement and progress in the upper part of the course often depend on slipping, which may occur over the smooth surface of the bed rock or within the loose mass. The angle of slope

* In petroleum areas (such as parts of Trinidad) mudflows abound where natural gas has forced wet mud to the surface through vents or fissures. This kind of mudflow is usually called a *mud-volcano*. Its characteristic feature is absence of stratification. (F.H.)

recorded for typical débris-avalanches ranges from 40 to 20 degrees near the head, diminishing to 15 degrees or less towards the terminus, where the momentum and the high water content of the material produce forward movement resembling that of a mudflow.*

(B) SLIDING MOVEMENTS.—LANDSLIDE OR LANDSLIP.

Landslide is defined as *the perceptible downward sliding or falling of a relatively dry mass of soil, debris or rock, or a mixture of these.* It usually occurs where the slope of the land is steep, causing rapid motion, though *creeping slides* have been observed. Sufficient water is needed for lubricating the slip surface; in excess, water gives rise under like circumstances to earth-flow, mudflow or débris-avalanche. The presence of snow or ice changes a landslide into a snow-avalanche or ice-fall.

There are five subdivisions of landslides, namely *slump, debris-slide, debris-fall, rock-slide* and *rock-fall.* These grade into one another depending chiefly on the nature of the material involved. They are described in the following notes.

A landslide may be considered as made up of three parts, namely, (*a*) the upper region from which the sliding mass becomes detached; (*b*) the middle course, and (*c*) the region of deposition, where the "toe" of the slide comes to rest.† The causes of landslide may be considered under two heads; those that are passive and concern only the nature and condition of the material involved, and active or initiating causes, including overloading, reduction of friction and of cohesion, removal of support, earth vibrations, prying action of ice formation, water-expansion and growth of tree-roots, and various human agencies.

(8) SLUMP.—*Downward slipping of unconsolidated earthy material moving as a unit, or as several subsidiary units, usually with backward rotation about a horizontal axis.*

A slump may be slow or rapid, but the displacement effected is usually small relative to the size of the mass that moves. A definite slip surface develops, which is typically deeply concave or conchoidal. A slump may therefore be described as a *shearing-slide* to distinguish it from a flow-slide, such as earthflow, that involves only a thin surface layer. It is commonly associated with subsidence. The shape of the slip-curve approximates to a hyperbola; it is frequently nearly vertical at the land surface. The term "surface of stability" is used to designate the boundary between the stable and the potentially moveable ground.

Slippage of the slump type is one of the most common landslide movements. It often results from undercutting of unconsolidated materials by river or sea-wave action. Removal of material by earthflow at the base of a slope may start a slump higher up the slope. The material affected may range from soil to talus or scree débris to large rock masses, but in each case there is essentially a cracking of the ground surface, followed by downward displacement with backward tilting—a general *settling down*, usually accomplished slowly.

Slumping necessitates the removal of support from beneath the toe of the slip-mass, which may result either from undercutting or earth-flow, from disintegration by weathering, or from outflow of underlying plastic clay layers or poorly-consolidated sediments. Sites liable to slumping should be avoided by railway and road engineers, since they may cause the destruction of artificial earth banks and the sides of cuttings.

Small-scale slumping may give rise to *terracettes*, variously termed "sheep-walks", "cat-steps", "cattle-terraces", &c., that commonly occur on grassy slopes. Darwin discussed such "ledges of earth on steep hillsides", used by grazing animals in Westmorland. Each step of a terracette consists of a small block which has rotated backward between cracks running across the slope. They are not uncommon in the tropics. Actually, they may *stabilise* a slope and not only tend to prevent further movement, but serve as catchments for surface soil-wash. On the other hand, their habitual use by cattle and sheep may produce bare strips and scars and encourage rill-erosion or gullying. Where the soil is not very firm, the constant treading by hoofs may aid the development of slip-planes and thus enhance the formation of terracettes. The individual steps may vary in height from a few inches to four or five feet, and in width from two to four feet. They may be regularly disposed or variably wedge-shaped. They develop best on slopes of 20 to 40 degrees; at steeper angles they may grade into shorter, crescentic slump-scarps, and on gentle slopes they disappear altogether.

(9) DEBRIS-SLIDE.—*Rapid downward movement of unconsolidated soil or debris, in which the mass slides or rolls forward, forming an irregular hummocky deposit.*

In the débris-slide, water is not plentiful, otherwise it would develop the characteristics of a débris-avalanche. It occurs most frequently

* Mass earth-movements of the débris-avalanche type are very common in the volcanic islands of the West Indies, for example, Grenada, St. Lucia, Dominica and Montserrat. Thus, disastrous débris-avalanches (erroneously described as landslides) occurred in the upper Cul-de-Sac Valley at Ravine Poisson in St. Lucia on 22nd November, 1938, following a period of intense rainfall. Severe undercutting of the hill-base by the flooded river, coupled with a high water content of the deeply-weathered clayey material covering the steep slope, and favoured by recent deforestation, are thought to have been contributory causes of this catastrophe. (*See* H. E. Box "Observations on the Landslides in St. Lucia, B.W.I., in November, 1938". *Empire Forestry Journal*, 18, 1, 1939, pp. 119-121, 4 pictures.) (F.H.)

† *See* also Report of the Building Research Board for 1937; *Dept. Sci. Indus. Res.*, London, 1938, H.M.S.O., pp. 101-105, in which the mechanics of landslip is discussed.—(F.H.)

along undercut banks or on steep talus-slopes or detrital cones, where the displacement of a single block may precipitate a débris-slide on a grand scale. Débris-slides are usually small, though they are of such common occurrence that they escape record. They are often initiated by earthquakes.*

(10) DEBRIS-FALL.—*Free falling of unconsolidated debris from a vertical or overhanging cliff, cave or arch.*

This is an unimportant type which grades into the débris-slide on the one hand and into rock-fall on the other. Few materials other than solid rock stand in vertical cliffs of any appreciable height, except *loess*, which is a fine, uniform, wind-blown deposit derived from ancient glacial débris accumulated in the Great Ice Age, occurring over vast areas in northern Europe, Asia and America.† The loess bluffs of the Mississippi Valley are 40 to 50 feet high; vertical slabs or columns, loosened by percolating water, topple forward from them or drop vertically if undercut. The caving-in of undercut banks of unconsolidated material is ranked as débris-fall, and is a common form of land wastage. Volcanic débris-fall often occurs as a result of earthquakes.

(11) ROCK-SLIDE.—*Rapid downward movement of newly-detached segments of bedrock which slide along bedding or joint planes or along faults.*

Rock-slide may involve enormous masses of material; thus, a rock-slide in Wyoming that occurred in 1925 displaced 50 million cubic yards of rock which descended some 2,000 feet obliquely down a dip-slope. The débris dammed a river and formed a lake five miles long.

Rock-slides are naturally commonest in rugged mountainous country, though they are less common than slumps and débris-slides.

(12) ROCK-FALL.—*Free falling of newly-detached segments of bedrock from a vertical or overhanging cliff, cave or arch.*

This closely resembles débris-fall, except that it affects only blocks and fragments of solid rock split off from the main mass by agencies such as percolating water aided by frost and alternation of high and low temperatures, causing expansion and contraction. There is no marked slip-plane as in rock-slide; the fall may be vertical or consist of a series of leaps and bounds down a steep slope.

Rock-falls are common in glaciated regions, along shore-cliffs, and on the walls of cirques occupying the heads of valleys. They are often initiated by earthquakes.

(C) SUBSIDENCE.

This is an earth movement in which there is no free side, and surface material is displaced vertically downward with little or no horizontal component. It is caused by the removal or compaction of underlying material, or by down-warping of the earth's crust. It usually takes place slowly*. Many cases are caused through human activities, such as mining, quarrying, oil-drilling, salt extraction and swamp-draining.

The type of surface phenomena produced by subsidence depends on the depth at which underground removal has gone on, the amount of removal, and the character of the overlying strata and of surface material.

Relationship of Land Movements to Climate.

Many of the types of land movement are world-wide in distribution and scarcely controlled by climate, for example the five landslide types, though *rock-slide* and *rock-fall* (which are included among the landslides) are decidedly favoured by frost-shattering in cold regions. *Subsidence* also shows little zonal distribution, except where sinking is caused by the solution of limestone, a process which proceeds only slowly in arid and in arctic climates. On the other hand, most of the creep types of land movement show marked individual ranges. Thus, *soil-creep* is especially prevalent in humid-tropical, sub-tropical and temperate regions, but is replaced by *solifluction* in regions having permanent ground frost.

Talus-creep and *rock-creep* are more active in regions where the climate is moderately cold and the freezing point is crossed a number of times in the year. In such zones, these kinds of creep comprise the main agent causing removal of the coarser products of rock weathering. Alpine *mudflow* also is a cold-climate phenomenon.

In humid-tropical, sub-tropical and temperate climates, where chemical decomposition of rocks is important, and where there is normally a dense cover of vegetation, land-creep movements, both slow and rapid, as well as landslides are particularly prominent. *Soil-creep*, *rock-creep* and *earthflow* are all able to operate beneath the mantle of vegetation: they are important though inconspicuous processes tending to round off the landscape.

In semi-arid and desert climates, the various types of land-creep and landslide are all more or less represented, though usually intermittent in their action, and in some cases dependent on occasional torrential floods, for example, *mudflow*.

* For example, in Montserrat, B.W.I. during the volcano-seismic crisis of 1933-37.—(F.H.)

† Some types of fine ash and sand, such as occur among the fragmental volcanic rocks of the West Indian Islands, stand out as cliffs bordering deep ravines, and resemble loess in this feature.—(F.H.)

* The natural formation of limestone caves and underground water-courses in limestone countries may give rise to subsidence, often on a large scale. When the rocky roofs drop in, interior basins (such as those that abound in Jamaica, B.W.I.) may eventually develop as striking geological features affecting scenery.—(F.H.)

Relationship of Land Movements to the Geomorphic Cycles.

All types of land-creep, both slow and rapid, as well as land-slide and subsidence, are very active in shaping the topographic forms of the earth's surface. They are potent agents in denudation and earth sculpture, especially during the early stages of land evolution while the topographic features are still young or immature. Slow creeping movements are conspicuous results of the operation of the humid fluvial cycle of geomorphic agency, particularly during youth and early maturity while valley-slopes are still steep. They may be slowly operative even throughout old age, and may constitute a much more important factor in producing mature well-rounded forms than is generally recognised. *Earthflow* and *mudflow*, which are relatively rapid movements, may prevail on gently-sloping valley sides or on river terraces, notably in clay strata. On the other hand, *debris-avalanche* disappears during the mature stage of the humid fluvial cycle, though very conspicuous on the steep slopes of youthful landscapes. Similarly, all the types of landslide are more prevalent in youth, becoming more rare as the valley-slopes flatten.

Mudflow is the main feature of the arid fluvial cycle, declining with age; *solifluction* is characteristic of sub-arctic and sub-alpine glacial cycles where the ground is permanently frozen, and morainic *creep* and *rock-slide* affect taluses and screes in all glacial cycles.

Addendum.*

Relationship of Land Movements to Erosion and Mass-Transport.

This aspect of land movement naturally is the one that most closely concerns the agriculturist and the student of soil science. In discussing the erosional aspect, especial consideration should be given to the *rate*, as well as the kind, of land movement. The chief factors that decide rate of movement are (1) steepness of slope, (2) water content and (3) nature of the material, including shape and size and mode of arrangement of its component fragments or particles which partly decide friction and cohesion.

Water acts both as load and as lubricant, as well as agent of transport. When in excess, the lubricating ability of water increases to infinity and viscous flow gives place to frictionless free flow, the discrete transported particles being completely separated, and cohesion diminishing to zero. Transportation by water becomes more facile as water content increases and the slope becomes steeper. This is the well-known *stream-flow* action, fully discussed in most textbooks of geology. The relationships between velocity, grade, load and abrasive power for stream-flow have been thoroughly studied by geologists and need not be considered here.

Sheet-flood and *slope-wash* represent less aqueous phases of stream-flow; they are responsible for what is usually termed *sheet erosion*. On the other hand, *rill-washing*, *finger* or *shoe-string gullying* and *gully erosion* proper may be regarded as variants of stream-flow or river action on an increasing scale. All are responsible for much land wastage, and various methods for their control have been devised.

The erosional damage and the extent of soil removal effected by land movements involving lesser amounts of water than these last-mentioned types have not yet been exactly assessed. They may be of great importance in humid-tropical countries, especially those tropical countries whose geographical evolution has not proceeded very far, and whose topography is still very young or immature, as for example, parts of the West Indies region.

The transporting power of *mudflow*, *earthflow*, and *solifluction* depends on the rate of movement which decreases in the order given, chiefly because of diminishing water content. In certain humid tropical countries, *mudflow* and *earthflow* may be responsible for great amounts of soil erosion; they certainly should be included among the soil erosion processes that are operative in highly-humid regions, and regularly recurrent during wet seasons. Similarly, *debris-avalanche* (another rapid land-creep movement) appears to be a highly effective, though intermittent, agent of soil erosion, causing catastrophic loss of surface soil in humid-tropical countries whose topography is steep. Cases are on record where large acreages of sloping land, sometimes whole fields, slip away from the bedrock and precipitate themselves into the valley below, during or following periods of heavy rainfall.*

Other types of land-creep (such as *soil-creep*) are difficult to assess as agents of soil erosion. Their operation is so slow as to be almost imperceptible, and the fact that they may cause movement beneath a blanket of vegetation, such as occurs in tropical forests, enhances their obscuration. That soil-creep may seriously disturb the sub-surface soil, and thus interfere with the proper growth and functioning of root-systems, must not be left out of account in assessing the possible damage caused by this type of earth movement, especially when considered as an ecological agent. Further, the complications introduced by soil-creep in the interpretation of soil profiles involving the relationships and significance of their various layers, zones and horizons, may be puzzling to the investigator, and should be given due consideration in areas where land movement is likely to occur.

* Most of the matter in this section is original; the book source from which the preceding information has been gleaned contains no specific discussion of soil erosion as such, nor of the agricultural implications of land movements.—(F.H.)

* Examples of serious débris-avalanche causing much land wastage have been reported from the newer volcanic islands of the West Indies, notably Dominica and St. Lucia.—(F.H.)

Certain kinds of landslide (for example, *slump* and *debris-slide*) as well as *subsidence* probably do not lead to spectacular loss of soil, though they may bring about serious disturbance of root systems. They may also lead the way to more effective kinds of movement involving soil transportation, such as *earthflow*, and in this sense they would be regarded as agents of erosion.

In conclusion, to quote from Dr. Sharpe's summary of his most helpful book; "Knowledge "of the nature and importance of mass-movement "phenomena is necessary to a full understanding "of geomorphic processes, and in many cases is "vital to the proper interpretation of the problems "of structural, economic or engineering geology, "stratigraphy, civil-engineering and soil "conservation" . . . "It has been shown that "mass-movement is not a rare and unique "geological phenomenon, but is continuously "active in greater or lesser degree".

The employment of the scheme of classification and the adoption of the definitions set out in this book should help materially in the building up of a more exact science of denudation and erosion, embracing not only geological processes but also those that have been induced by man's interference with the geomorphic cycles.

A SIMPLE WATER LIFT.

By L. D. Cleare.

(*Department of Agriculture, British Guiana.*)

The small cultivator in the tropics is often faced with the difficulty of bringing water to his crops in dry seasons, and, in some of the wetter countries such as British Guiana, with the equally difficult problem of removing excess of rainfall during the wet season.

From the earliest days primitive contrivances have been used by peasant cultivators in Eastern countries, in the form of water wheels (Persian wheels, &c.), and water lifts, some of which are highly efficient. In the West Indies generally there has been little attempt at anything of this nature, as far as the writer is aware, although there is a definite need for such. In British Guiana, when the necessity arises, resort is made to baling with baskets operated by long rope handles, or to dippers, which are usually nothing more than empty boxes suspended on tripods or other supports.

The water lift described here although somewhat more advanced in design than the contrivances now used in this country, is by no means complicated or difficult to construct; nor is it expensive to make. No originality is claimed for the idea as it is based on similar devices long used in Eastern countries and Europe. Simplicity of construction and efficiency are the features in its favour. Even in these days of improved methods, such features are important when costs have to be considered. Also the amount of water that can be lifted is much greater than by the methods now in use in this country, and the lift is easier to work.

In a general way this device may be described as a wooden tube through which a series of paddles pass on an endless belt, the motive power being supplied by operating a hand (breast) wheel at the upper end, the belt passing around a drum on the axle of this wheel and a similar but smaller drum at the lower end. The lower end of the contrivance is placed in the water supply and, as the hand wheel is turned, the paddles lift the water up the tube, delivering it at the top whence it may be led to or from a particular area.

The details of construction of this water lift are given in the accompanying drawings (Fig. I) and photograph (Fig. II) so that no elaborate description is necessary. In order to facilitate operations a bar with a counterpoise is fitted opposite to the handle, a weight of 4½ lb. being sufficient for this purpose. The endless belt on which the paddles are fitted is made of canvas, the sides of which are turned over (hemmed) to prevent fraying, and the paddles are affixed by means of galvanized iron flat-headed nails. The lower end of the tube is screened with ¼" galvanized wire mesh to exclude twigs which otherwise enter the tube and block it. It is desirable to have a 'horse' to support the upper end of the lift as shown in Figure II. This also serves to give stability and to regulate the height for operating according to the position in relation to the water supply.

The wood used should be well seasoned so that it will not be affected by the water. It is presumed that local woods will be used in general so no particular woods have been specified. In the lift shown in Figure II, Crabwood (*Carapa guianensis* Aubl.) was principally employed with Greenheart (*Nectandra Rodioei* Hook.) for the axles, handle and parts requiring special strength.

The following is a list of the materials used in the construction of such a lift with a length of ten feet overall and a tube of eight feet:—

Hull	...25 ft. 12 × 1 in. Boards.
Paddles	...15 ft. 12 × 1 in. Boards.
Drums	... 5 ft. 12 × 1 in. Boards.
Straps, &c.	... 4 ft. 12 × 1 in. Boards.
Axles	... 3 ft. of 1½ × 1½ in. Scantling.
Belt	...3½ yds. Canvas.
Bolts	...1½ doz. 2½ in. × ⅜ in.
Nails	...3 lb. Galvanized.
Screws	...2½ doz. Galvanized.
Pipings for bearings	4 pieces brass tube each 4 in. in length.
Counterpoise	...weight 4½ lb.

It has been estimated that one man working a lift of the dimensions here given can move approximately 3,000 gallons of water an hour under ordinary pressure. As in all such devices there are limitations as to the height and quantity of water which can be lifted in relation to energy expended, and dimensions will vary accordingly. The higher the lift the smaller must be the bore of the tube for the same expenditure of energy.

A SIMPLE WATER LIFT.

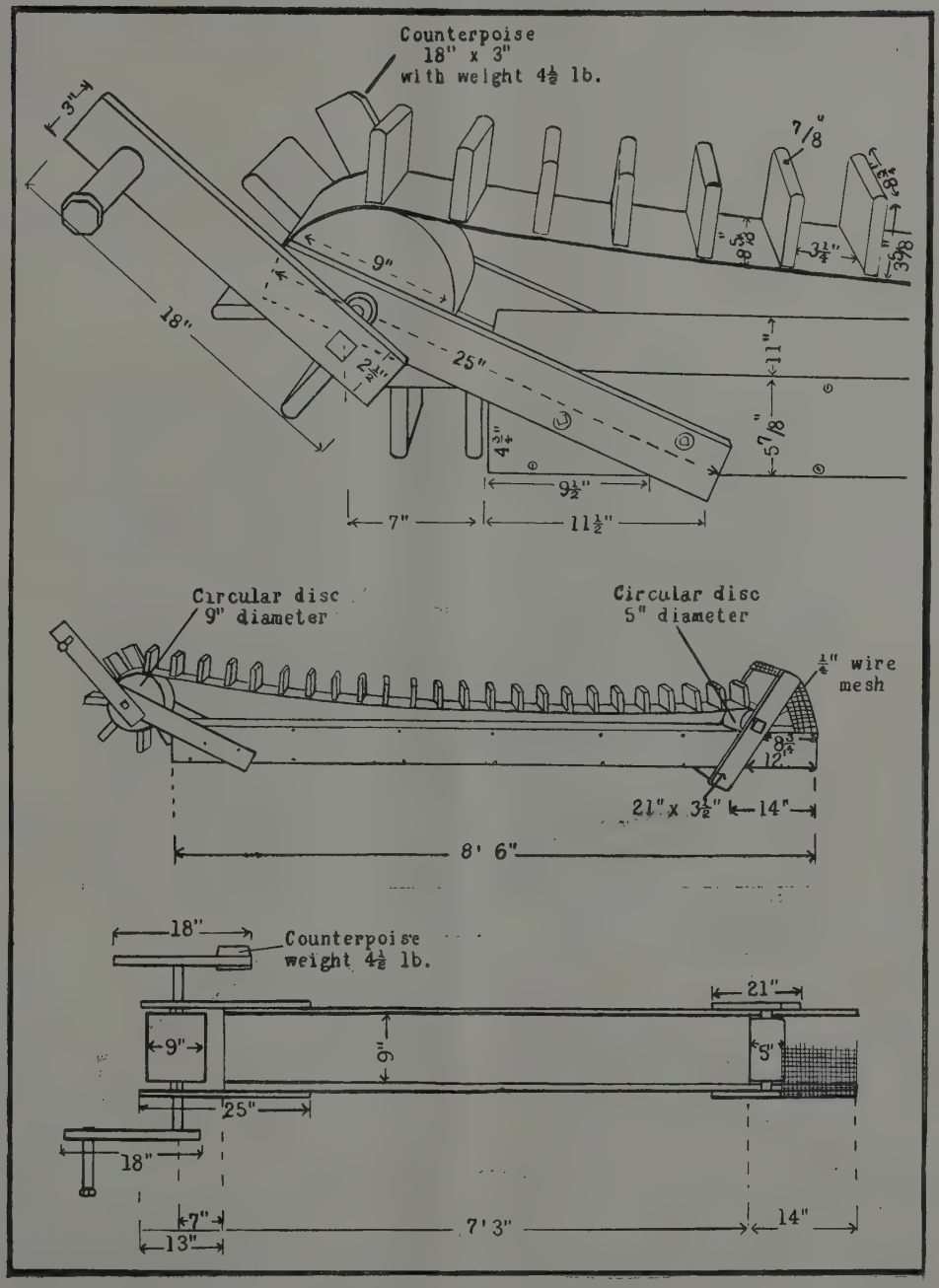

FIG. I,

A SIMPLE WATER LIFT.

Fig. 11.

OVERPRODUCTION AND SCIENTIFIC IMPROVEMENT IN AGRICULTURE.

By A. L. Jolly.

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It is proposed in this note to discuss an apparent paradox in agricultural economics: when agriculturists complain of general overproduction of a commodity, scientists and economists apparently direct their energies to *increasing* its production! An understanding of this apparent discrepancy is of considerable practical importance to the agricultural industry; if the farmer does not understand why the scientist strives for increased production, or if the scientist does not understand why the farmer complains of overproduction, no co-operative effort between them can be expected.

When the paradox is analyzed it is found that neither of the two sides are stated in precise terms; the slight mis-statement on both sides results in an apparent absurdity on the whole. The farmer, when he talks of overproduction, means something different while the scientist does not direct his efforts precisely to increasing production. Let us consider the farmer's point of view first.

The farmer's statement that a commodity is overproduced or underconsumed (which means precisely the same thing), when taken literally, signifies that production is on such a scale that part is not consumed. But the fact that some of the production is unconsumed is not, in itself, a problem to the farmer. His problem is to obtain the maximum profit from the commodities he produces; it does not matter to him if he sells only half his produce provided that that half yields a higher total profit than any other volume of sales. Indeed, there have been cases where farmers have actually created a condition of overproduction or under-consumption for their own financial gain. For instance, Californian fruit growers have, on occasions, refused to harvest the whole of their crop because they could obtain higher profits by withholding a part of their produce. These farmers have voluntarily created an unconsumed surplus production.

It is not the possibility that a portion of the supply may never be consumed which worries the farmer, it is the possibility that he may have to dispose of the whole of his supply in times of abundance at a low price. It is underprice and not overproduction about which the farmer is really complaining.

It may be remarked that genuine overproduction, that is the production of an unconsumable surplus of agricultural commodities, is a practically non-existent state of affairs. It may sound plausible that man can only eat and drink so much and that therefore the demand for agricultural commodities is inelastic, and unconsumable surpluses may arise. But this reasoning takes no account of certain very important facts about agricultural consumption. First, that among the human population very few consumers have reached satiety in all foods and many have not reached satiety in even the most prosaic foods such as cereals. Second, that the human population is not the only consumer of food products; animals, which themselves yield food, are also large consumers of agricultural staples; thus the potential consumption of cereals in the form of animal products is large. Third, that urban industry is a large and potentially larger consumer of agricultural products. Such products as cotton, wool and rubber go entirely to industrial consumers whose demand is elastic; milk also is used in the manufacture of many purely industrial products, while the scope for industrial utilisation of other agricultural commodities, particularly cereals, is enormous.

It may be stated that a permanent increase of 50 per cent. in the production of agricultural commodities could be easily consumed if offered at a sufficiently low price.

Most farmers will agree that it is low price, arising from alleged overproduction, which is the real cause for complaint. They maintain that they rightly require a "fair" price; a price which would permit them to continue their existing organisations and methods of cultivation and earn a moderate profit. The use of the adjective "fair" is particularly appropriate because a leading economist in the past has discussed such a price in some detail. The unfortunate feature of the adjective is that it has a double meaning—the farmer uses one, the economist the other. The farmer means by "fair", equitable; the economist, sufficient, that is to maintain production in an averagely efficient and progressive state.

Actually the doctrine that the price of anything whether of commodities, labour, land or capital, should be fixed so as to be equitable for all concerned is comparatively new. The older idea was that everyone with anything to exchange, should drive the best bargain possible. The difficulty of putting the newer idea into practice is the difficulty of deciding what is an equitable price and what is not; to the seller a high price seems equitable, to the buyer a low price seems equally so.

The danger of attempting to fix the price of anything according to equity is that the individual enterprise is liable to be damped. The individual, who receives more than his due, will tend to become complacent; the individual who through no fault of his own receives less will feel frustrated. Neither frame of mind is conducive to energetic and self reliant enterprise.

This danger makes it improbable that a system of fixing prices arbitrarily will come into universal usage in the immediate future. For the present farmers will have to content themselves to a large extent with whatever price they can command. If the volume of production is great, consumers who are prepared to buy only at low prices will enter the market; the ruling price level will therefore be low. If low prices persist the farmers who are least fortunately situated and who are

most dissatisfied can retaliate only in two ways, either by discontinuing production or by reducing costs of production to a level at which the ruling price is profitable. Most farmers because of the specialised nature of their occupation cannot withdraw from production; their only alternative is to attempt economies in production.

The problem the scientist has to solve when there is alleged overproduction consists therefore not of reducing the volume of production but rather of reducing costs. Since it is the price *per unit* which is low, the problem is to lower the cost per unit. This cost can be reduced either by curtailing the customary expenditure in such a way that the yield is not proportionately reduced; or by incurring additional expenditure in such a way as to secure a proportionately larger increase in yield.

Of the two methods whereby cost per unit can be reduced the first, the curtailment of expenditure, appears at first sight to be the more logical; when times are bad the natural procedure is to economise in expenditure wherever possible. In practice, however, this is not the soundest way of tackling the problem for the following reason. Only a small part of the expenditure incurred in an agricultural enterprise is for purely current operations, such as harvesting, which affect the enterprise at the time they are actually performed. Other operations such as cultivating, manuring, pruning, &c. are similar to the industrialist's expenditure for upkeep of capital: their effect is not temporary but influences the economy of subsequent production. In fact the curtailment of expenditure generally means the reduction of capital in the enterprise; the temporary effect of "living on capital" is of course to increase profits but after the temporary effect has passed the enterprise is worse off than before. The enterprise is less efficient because it is more costly to produce anything with less capital productively applied. The policy of pulling in one's belt in agriculture in times of depression has therefore little to recommend it from the economist's point of view.

The alternative of increasing expenditure and more than proportionately increasing the yield, though difficult to achieve in bad times, is to be preferred. Additional expenditure can be incurred in one phase of production only, such as manuring, or it can be incurred generally in evolving more efficient methods of production such as the evolution of a superior yielding variety of a crop. The former avenue of increased expenditure can be undertaken by the farmer himself; the latter must be usually explored by some corporate scientific body. Both of course involve increased expenditure whether for the farmer's manures or the scientist's salary: the source of funds to meet the expenditure, though naturally of interest to the farmer, does not affect the discussion.

Something should be said on the merits of these two approaches to increased expenditure. The farmer spending extra on manures or machinery is essentially increasing *existing* capital investments. The scientist through his services is generally applying capital in a new way; his task is that of evolving new methods of production by the evolution for instance of new superior varieties of crops.

Most people are aware that as capital is applied to one phase of agricultural production in increasing amounts it becomes less and less productive—that is, the profit from each fresh investment becomes less. The scope for increases in profit by successive applications of capital in one particular form is therefore limited, ultimately the position is reached when no increase in profit is obtained. If production in times of prosperity has been managed efficiently the maximum profit for all existing forms of investment should already have been obtained; under these circumstances additional investment cannot result in higher profits or the arrest of any decline. In short the farmer's only hope of increasing his profit by his own efforts in bad times is the careful scrutiny of previous expenditure he has incurred in good times; his hope is the discovery of wasteful expenditure in the past and the remedying of past extravagance.

The assistance the scientist can give to the farmer by the evolution of more productive methods of management can be very great. The capital represented by the scientist's work is applied in new ways. There would be scope in the application of capital in these new ways for far larger economies than from mere additions to existing capital investments. Further, the law of diminishing returns (decreasing profit from successive application of capital) does not operate so strongly—sometimes not at all—for initial investments in any particular form.

The scientist's efforts to increase yield are beneficial to the farmer and the community at large in another way. By increased yield it is possible to secure the same total production from a smaller area of land. This smaller area will presumably be the most suitable, so that the average quality of the land under cultivation will be increased. The land thrown out of cultivation may be a complete loss if it is abandoned, and the capital invested in it will deteriorate to nothing. More often, however, only part of the capital is lost because the land can be converted to the cultivation of some less exacting crop. Not only is the efficiency of the main crop increased because of better quality land but the efficiency of the less exacting substitute crop is also enhanced. The land discarded for the main crop must obviously be more suitable for the substitute than any previously used so that the average quality of the substitute land is also increased in the process of improving the main crop.

Thus the apparent absurdity of remedying alleged overproduction by apparently increasing production is actually sound when examined in detail. Overproduction is really under price and low price can be most effectively countered by increasing yield (not necessarily production). In fact the increase of yield by the evolution of new methods of production is the most fruitful way of decreasing costs.

REVIEWS.

TROPICAL NUTRITION AND DIETETICS.

By Lucius Nicholls. *Ballière, Tindall and Cox*, London, 1938. pp. 158. Price *7s. 6d.*

The appearance of this book is very opportune at a time when many tropical countries are finding it necessary to become more self-sufficient in foodstuffs. An indiscriminate substitution of locally grown foods for certain imported provisions may lead to a lowering of the nutritional status of the people with a corresponding increase in deficiency diseases. To avoid this possibility it is essential to understand the food value of the locally grown provisions and the nutritional requirements of the people. The value of Mr. Nicholl's book lies in the concise way in which these, and other aspects of tropical nutrition, are described. In the last few years much nutritional work has been done in several tropical countries; the results of dietary deficiencies have been studied, attention has been paid to the diets in use among general populations and large numbers of foodstuffs have been chemically analysed and biologically assayed. In "Tropical Nutrition" the salient points of these investigations are collected under one cover and the general principles of nutrition and dietetics are briefly described.

In the opening chapter the author discusses summarily the functions and chemical natures of carbohydrates and fats, and then turns his attention to the proteins. The nutritive value of proteins, and the protein requirements for maintenance and growth are clearly stated. An important section of this chapter deals with protein requirements in relation to malaria and other tropical diseases. It is here pointed out that "During a bout of fever the digestion and absorption of food is below normal and the wasting which takes place must be made up from the proteins of food taken after the subsidence of the fever. The children in tropical countries are so frequently suffering from one or other prevalent infection that the resulting increased need of proteins is far from negligible".

In Chapter II the author discusses the mineral elements necessary for growth and health, with special reference to those liable to be deficient in human diets, *viz.*: calcium, phosphorus, iron and iodine. Most of the minerals required are supplied in the foods consumed and, as the quantity of different minerals in foodstuffs of vegetable origin depend upon the nature of the land on which they have been grown, mineral deficiency diseases may prevail among people who subsist largely on foodstuffs grown in "poor" soils. An insufficiency of calcium or phosphorus is a common cause of mineral deficiency diseases, and diets which are of a predominately vegetarian nature should be supplemented with an adequate supply of milk which is rich in both these elements.

The vitamins are considered in some detail (Chapters III and IV). The author pays considerable attention to the pathological effects of vitamin deficiencies and in this connection writes "The lower classes of the populations of many tropical countries subsist on poor and monotonous diets . . . and various signs and symptoms of deficiency diseases . . . are rife among them". This state of affairs must be ascribed, to some extent, to an indiscriminate choice of foods, for all the vitamins (with the exception of vitamin D) which are essential for correct nutrition and good health are found in relative abundance in one or other of many tropical fruits or vegetables. Deficiency diseases can be avoided if the vitamin values of available foods are known and the diets of the people studied and supplemented, where necessary, by a correct choice of foods.

Several important points are revealed in these chapters some of which are here summarised. Vitamin D is present in fair amounts only in relatively expensive foodstuffs of animal origin such as butter, eggs and fat fish. It occurs therefore, in very small amounts in the diets of the poorer classes in many tropical countries. It is, however, formed by the action of sunlight on the skin, and most children in the tropics obtain an ample supply of vitamin D in this way. Ill health due to a deficiency of vitamin B1 is common in many parts of the tropics where the lower classes live mainly on polished rice inadequately supplemented with other foodstuffs. This is deplorable in view of the wide distribution of this vitamin in naturally occurring foods. Scurvy is not very common among adults in most parts of the tropical world, but cases occur among young children who have been weaned on rice or maize gruels, tinned milk, or proprietary foodstuffs deficient in vitamin C. Where there are dense populations the diets of the children of the poorer classes are seriously deficient in vitamin A, and the growth of many of them is subnormal. One of the most significant discoveries of recent times has been that avitaminoses may not only be due to deficient diets but also to faulty absorption of vitamins following gastro-intestinal disorders.

After a brief discussion of condiments, beverages and roughage (Chapter V) the author describes in Chapter VI, the energy value of foods and standard allowances for prescribed diets. In this connection the author writes "The balancing of diets for the poorer classes, so that the proteins will be adequate in quality and quantity, presents great difficulties for economic reasons, and it is obviously unreasonable to prescribe diets of prohibitive cost". The chapter contains much useful data on the carbohydrates, proteins, fats, minerals and vitamins in relation to human nutrition and should be of value to those who are called upon to prescribe a satisfactory diet at a

minimum cost. Milk contains a better mixture of protein than any other foodstuff and it has been recommended that all children should receive 1½ to 1¾ pints a day. Unfortunately, as Mr. Nicholls points out, " there are large areas in the tropics where the number of cattle is insufficient to give effect to this even to a limited extent ".

One of the first necessities for the study of the nutrition of a population is the determination of the actual diets in use among the various sections of the people. The two methods of doing this are described in Chapter VII. A table is also included which gives a general summary of a dietary survey and the author discusses a few of the large number of points of information which the survey revealed.

Practically the whole of Chapter VIII is a tabulation of general averages of analyses of foodstuffs grown in India, Java, Ceylon, the Philippines, Malaya and South America. This classification should prove an excellent guide to all workers on tropical nutrition. The various foodstuffs are listed in sections under such headings as pulses, cereals, roots, vegetables, fruits, &c., and data are given regarding the moisture, protein, fat, carbohydrate, ash, fibre, calcium, phosphorus, iron and vitamin contents of each. The calorific values are also recorded and altogether some 220 foodstuffs are considered.

The prescription of diets is next considered briefly (Chapter IX) and here the author points out that " when attempts are made to improve the diet of the poorer classes, it is necessary to study the local foodstuffs most available and the prices of them. The diets commonly used and their food values must be first determined, and then by exchanges or additions of other foodstuffs any deficiencies may be corrected ". As an example the author describes the food values of a type of diet in common use among the poorer classes of southern Asia, pointing out its deficiencies and how these may be eliminated. The diets of institutions are also considered in a similar light and useful information given regarding the nutritional requirements of school children of the poorer classes.

Signs and symptoms of dietary deficiencies are described in some detail in Chapter X. It is here pointed out that " Diseases such as scurvy, beri-beri and pellagra are extreme conditions due to dietary deficiencies, and only in recent years has it been realised that manifestations of a less profound nature are prevalent in many tropical countries and are due to various shortages in the diets ". The many symptoms described are summarised in a table which includes also the dietary deficiencies to which such symptoms are attributable.

The final chapter deals with public health activities in relation to tropical nutrition and includes information on the assessment of the nutritional state, outbreaks of food poisoning, and the teaching of dietetics to school children and others. Appendixes follow which describe methods for the estimation of vitamins A, B, and C, instructions for dietary inquiries, a typical School Inspection Form, and the principles underlying the A. C. H. Index of Nutrition.

The many aspects of tropical nutrition that are considered in this book make it extremely valuable to all who are concerned with the problem of raising the nutritional status of the people. In a precise and well-written work, Mr. Nicholls describes how the problem should be tackled and how, by scientific methods of approach, it can be overcome. In addition to the large amount of information which it contains the book includes 49 tables, other tabulated data and nine figures.

H. F. B.

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THE INTERNATIONAL NOTATION FOR TAPPING SYSTEMS AND ITS USE IN THE TABULATION OF YIELD RECORDS. By E. R. Guest (Communication No. 239).

A STANDARD INTERNATIONAL NOTATION FOR SYSTEMS OF TAPPING HEVEA. By E. R. Guest (Communication No. 240).—*Jnl. Rub. Res. Ins. of Malaya,* Kuala Lumpur, Oct. 1939, Vol. IX, pp. 142-170.

The number of the Journal of the Rubber Research Institute of Malaya referred to contains two important articles by Evan Guest.

The rubber tree is one of the world's chief crops; but the amount of experimental work carried out with the object of finding ways of increasing its yield has been little in comparison with that carried out on many other crops, some of them of less value than the rubber tree. One difficulty, out of a number of difficulties which beset the investigator into the processes which are concerned in the production of a yield of rubber, has been that, hitherto, the systems of notation, used in describing different tapping systems, are not only numerous, but are such that the same symbols are used by different workers with different meanings, and such that the same meaning is expressed by different symbols, so that it is often impossible to compare yields in different districts. Mr. Guest rightly points out that the present confusion in tapping notation must be removed, if proper use is to be made of the results of research workers in different parts of the rubber world. His papers, therefore, are important in that they describe the different systems in present use, assess the value of the components of each, and recommend a standard system, in which each symbol shall have a proper reason for being called into existence, and shall have a definite value.

V. H. W. D.

INVESTIGATIONS WITH A VIEW TO THE BIOLOGICAL CONTROL OF HOUSEFLIES IN FIJI.

By H. W. Simmonds.
(*Formerly Entomologist, Department of Agriculture, Fiji.*)

[*Houseflies are a cause of serious concern to the agriculturist because they can breed in great numbers in pen manure and compost heaps, and may thus give rise to a conflict between the maintenance of soil fertility and the enforcement of public health regulations. Great attention has been devoted to the problem, and methods of solving it are known, though their application may require considerable expense and labour, and constant vigilance. Among the best known of these are rapid disposal of manure, the use of covered pits, chemical treatment with borax, hellebore, &c., and the frequent turning over of heaps of manure in such a way that all the insects are killed by the heat of fermentation in the interior.*

Little attention has been paid to the problem of cattle droppings lying in the field and H. W. Simmonds has shown how important these may be as a cause of outbreaks of flies and fly-borne diseases. The only methods of control that appear to offer any hope, short of eliminating or confining the cattle, are biological—the introduction of natural enemies of the flies, and of dung-beetles to compete with their food supply. Mr. Simmonds was entrusted with a special investigation of the problem by the Government of Fiji, aided by a grant from the Colonial Development Fund. This paper is a slightly revised form of the report submitted by him. It is to be hoped that his work will ultimately lead towards a further success in biological control, in which outstanding achievements have been made by entomologists in Fiji.—Editor.]

Introduction.

Until about thirty years ago, houseflies (*Musca domestica* L.) were excessively abundant in Fiji. Annual epidemics of dysentery of the severe *Shiga* type were attributed to the increase in their numbers during the hot season and they were connected also with the prevalence of typhoid and eye disease. About 1910 their numbers began to diminish and in some districts they ceased to be troublesome. This improvement was shown by Illingworth to be due to the accidental introduction of a predaceous ant, *Pheidole megacephala* F., which destroys the eggs of the flies and, when it can reach them, the larvae. In certain districts, however, especially where cattle were kept, flies continued to assume plague numbers in the hot season and since 1931 localised outbreaks of *Shiga* dysentery have reappeared, and eye disease of cattle has occurred.

In 1928 the writer was able to show that these local summer outbreaks were generally due to the fact that Fijian houseflies were able to use cattle droppings as they lay in the field, as a normal breeding medium in addition to the customary rubbish dumps, human faeces, stable dumps, &c. He found that this occurred also in Java and Malaya.

Experiments then showed that in Fiji temperature did not directly control the numbers of flies, but that seasonal outbreaks were the result of a combination of climatic and biological factors. Under the atmospheric conditions prevalent from November to March, the surface of the droppings does not harden sufficiently quickly to enable the ants to pass over it and remove the fly eggs before the larvae hatch and gain the safety of the interior.

In the course of these investigations two true parasites of the fly were found—*Spalangia muscidarum* Rich., a pupal parasite and *Eucoila* sp., which attacks the larva and emerges from the pupa. The latter was always found to be rare. One or two minute Staphylinid beetles were generally present, doubtless destroying some of the smaller maggots.

Early Introduction of Insects to Control Houseflies.

In the hopes of reducing the available food supply for the maggots, and of causing cattle droppings to dry up before the maggots had time to complete their development, attention was turned to the dung-beetles of the family Copridae. Through the good offices of the Hawaiian Sugar Planters' Association, a shipment of 615 adults of *Copris incertus* var. *prociduus* Say, a native of Mexico which had been established for some years in Hawaii, was received in 1929. The beetles were successfully established near Suva. They did not spread rapidly, however, and do not appear to be of much value. Nevertheless the writer has been greatly impressed by the efficiency of certain dung-beetles in South Africa, which sometimes remove a dropping in twenty-four to thirty-six hours.

Attention was next turned to predaceous insects, and with the assistance of the Imperial Institute of Entomology at Farnham Royal large numbers of *Mesembrina meridiana* L. were imported in 1931. These flies have predaceous larvae which live in cattle droppings. They appeared to survive for one generation in Fiji, but met with unfavourable weather and were not seen again.

In 1936 an African parasite of housefly pupae, *Dirhinus* sp.?, was imported, again by the kindness of the Hawaiian Sugar Planters' Association. In the laboratory it bred freely on pupae of houseflies and Sarcophogid flies. Large numbers were bred and liberated but though this fly is more robust and lives longer than *Spalangia*, as well as having a shorter life-cycle, it is doubtful whether it will prove of much value against the housefly. It is hoped that it may be of some use against the more slow breeding fruit-flies.

Investigations in Malaya, Java and Natal, 1938-39.

On a previous visit to Malaya and Java the writer observed the remarkably general absence of houseflies, despite the fact that they breed there in the droppings of cattle and buffalo. This suggested that biological agents were at work inhibiting their increase, and offered a hope that these agents might be of use if transported to Fiji.

On the arrival of the writer in Java in 1938, the Director of the Instituut voor Plantenzickten was kind enough to arrange for collections of the beetle fauna of cattle droppings in the vicinity, and a Histerid beetle, *Hister chinensis*, was found in the first collection. It was sufficiently large and abundant to offer encouraging possibilities. Small Coprid dung-beetles were also present but they were regarded as of negligible value compared with a predator such as *Hister*.

Laboratory tests showed that a single *Hister chinensis* could eat ten to twenty full-grown fly maggots in twenty-four hours, and that the beetles could survive without food for fifteen days, with a low mortality rate. It was concluded that these beetles were of major importance in reducing the numbers of all flies breeding in cattle dung, such as houseflies, hornflies (*Lyperosia*) and *Sarcophaga*, and that its introduction to Fiji was desirable. This introduction is described below.

In Malaya *H. chinensis* was found to be scarce, probably owing to soil conditions. A minute red ant was observed removing dipterous eggs as *Pheidole megacephala* does in Fiji, but fly maggots were sometimes found in abundance, and biological control of flies did not seem to be so effective as in Java.

Though houseflies are usually comparatively scarce in Java and Malaya, as stated above, this is not always true. In Malaya they were found in great abundance at Bentong, near Raub, where they were swarming over produce in a market; on the Batu Road at Kuala Lumpur, where they may have come from a neighbouring Indian dairy, and at Serdang, breeding in manure heaps of a dairy farm. The writer was informed that a severe outbreak at Fraser's Hill had been traced to a dairy farm there. At Malacca also, Muscid larvae were numerous in cattle droppings in the field and in manure heaps—in none of these was *Hister* found.

In Java, despite the much larger number of cattle, flies were very scarce almost everywhere, suggesting that some powerful factor was holding them in check. At a few places they were exceedingly abundant and the nature of these was significant. One was the city dump at Batavia and another at Tanjong Priok, where cattle are few or absent, and where conditions are therefore unfavourable for dung-beetles.

In Natal some Muscid larvae were found in cattle droppings, and houseflies, although not a serious pest, were fairly numerous at some places. A large and powerful Histerid, *Placodes caffer* Er., was present though apparently not numerous at the time of the writer's visit. The droppings were attacked by many species of Copridae, which often completely removed them within a few hours, whilst almost all of them were so reduced in bulk that they dried up rapidly, leaving little food for fly maggots. About Durban *Onitis alexis* Klug. was generally the most abundant dung-beetle whilst at Umhlali, according to a personal letter from Dr. Naude, *Copris urus* was most efficient. Probably the light soils and dry climate of South Africa increase the efficiency of these beetles, but the small *Copris incertus*, also a native of comparatively dry country, has done very well near Suva and also in Samoa, and the writer believes that the larger South African species are worthy of a trial in Fiji.

Introduction of *Hister chinensis* to Fiji, the Solomons and Samoa.

The first consignment of *Hister chinensis* for Fiji, consisting of 810 adults packed in a wooden box, was despatched on 24th October by air from Batavia to Sydney, whence, after feeding, they were shipped by steamer to Suva. They arrived in good condition and about 650 were released near Suva. The second consignment of 830 adults left Batavia on 9th November by the same route but packed in a kerosene tin, to retain more moisture. They arrived in excellent condition and 800 were liberated, also near Suva. Early reports suggest that the beetles have met exceptionally unfavourable weather conditions which may prove fatal.

As the Hornfly (*Lyperosia*) in the Solomons also breeds in cattle droppings the writer recommended the introduction of *H. chinensis*. This was done by the kindness of the Dutch authorities in Java. The second consignment of beetles arrived in good order, and they were taken over by Messrs. Lever Brothers' officer, Mr. Love, who liberated part of them, retaining a few to breed. He succeeded in obtaining eggs and larvae, and also recovered larvae in the field, and will no doubt publish his records later. The writer takes this opportunity of congratulating him on his successful work and of thanking Messrs. Lever Brothers for Mr. Love's notes on his technique.

A consignment of beetles sent from Java to Samoa, through the good offices of the Dutch authorities, arrived in excellent condition. It is too early to discover whether they are established, but conditions should prove very favourable. Muscid larvae are exceedingly abundant in cattle droppings in Samoa. *Copris incertus*, imported from Hawaii on the writer's suggestion in 1933, is now abundant every where in Samoa.

If *Hister chinensis* is established in Fiji, the Solomon Islands and Samoa, it may be expected to prove a very valuable factor in control of houseflies. In the event of failure of the above introductions, due to adverse conditions after liberation of the beetles, further attempts to establish them should be made. It must be remembered, however, that there may be a long interval between liberation and recovery, as the beetles, which are long lived and hardy, are likely to scatter considerably. The Histerid beetle, *Plaesius javanus* Er., which was introduced by Jepson to control the banana borer (*Cosmopolites sordidus* Germ.) in Fiji, was not found to be well established and doing good work until eight years after its introduction.

A.M.A.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Base Exchange Resins.

This entirely new kind of synthetic resin resulted from a fundamental study begun many years ago by the Department of Science and Industrial Research, London, on water-softening processes. The discovery was made, not merely that certain types of synthetic resins function as powerful base exchange media in a manner similar to the natural and artificial zeolites, but that in many cases the synthetic resins were more powerful and also could be adapted to a much wider range of conditions, both in anion and cation exchange. Also, their physical properties and chemical resistance offer certain advantages. It is perhaps in these differences from the zeolites, rather than in any similarity, that their commercial possibilities lie. In water purification, the degree of purity required, or the particular anions or cations to be removed, determine the type of resin used. If the removal of only the metal ions is required, the cation or base exchange resins can be used. Similarly, the acid exchange resins can be used alone for removal of the acid ions. In general, however, the combination of both types is used. The base exchange resins remove the metal ions from the water, forming mineral acids. In removing the acid radicals, the acid exchange resins liberate hydroxyl ion, which neutralizes the hydrogen ion previously formed. Thus the hardness and solids content of the treated water are markedly reduced and, theoretically at least, the effluent is as pure as distilled water. Even in commercial units, very efficient purification is effected. The resins are regenerated by acid or alkali, depending on the type.

Although there are no units in operation in the United States, commercial application has been established in Europe. Under the corresponding German patents, the I. G. Farbenindustrie in 1938 began offering a series of synthetic resin water-softeners under the trade name "Wolfatits", and these have met with considerable success. It is reported that several plants have been built, and are operating satisfactorily. In England at least, two licensees are developing the process. The preliminary research work is essentially complete, and many improvements in original resins have been made as a result of the investigation. The commercial development of this class of resins is to follow in the very near future.

Among the various uses which have been suggested for these resin exchanges are the purification of water, either to give substantially pure water or to remove certain objectionable constituents, such as calcium ions; in textile dyeing and finishing; the purification of water for high-pressure boilers; the removal of traces of metal. The general need for purified waters for processing textiles, laundering, chemical processes, and for steam generation, would indicate that these resins will find wide use.—(*Ind. & Chemical Eng., News Edit.*, Vol. 18, p. 390, 1940.)

* * *

Cryolite as Insecticide.

Fluorine compounds have so far proved the most effective substitutes for arsenical insecticides. Sodium fluosilicate, a by-product in the manufacture of acid phosphate, is being used extensively in the United States for baits in the control of grasshoppers and cutworms. Cryolite, a compound of sodium, aluminium and fluorine mined in Greenland, is very effective against fruit pests, such as codling moth and apple flea weevil, and for vegetable pests, such as flea beetles. S. Marcovitch writes (*Amer. Fruitgrower*, Feb., 1940) on the use of cryolite in apple orchards. The mineral, which is used mainly in the manufacture of aluminium, is ground to a fine dust occupying about 50 cub. in. to the pound. Like lead arsenate, it acts as a stomach poison, but is more effective than the former against codling moth. It has less sticking power, however, and is therefore most effective in dry seasons. It has no poisonous effect on the soil, a great advantage over arsenical compounds, which have rendered some soils in America unfit for crops. Another advantage is that it is non-poisonous in the amount likely to remain as spray deposit on apples. The amount allowed by law is 0.02 grain per lb. Fluorides present in drinking water to the extent of 1 part per million cause mottling of the teeth of residents in some parts of Arizona. Cryolite on apples has been shown to be free from this objection. In contrast to lead arsenate, cryolite appears to have no injurious effect on apple foliage. As many as seven applications in a season have been given without causing defoliation or damage to fruit. In some seasons, however, damage to peach fruits, known as 'tip-end injury', has occurred.—(*Nature*, Vol. CXLV, No. 3683, p. 865, 1940.)

Vitamin C Content of Some Fruits and Vegetables.

The following notes are abstracts from *Journal of Chemical Education*, Volume 17, Number 4, 1940, pp. 180-182.

Many factors, both external and internal, have been reported as affecting the antiscorbutic vitamin (Vitamin C; ascorbic acid) content of fruits and vegetables. Significant among them are length of time and conditions of storage, methods of cooking and processing, variety, stage of development, climatic conditions, and kind of soil and applied manures. This explains why discrepant results for Vitamin C contents have been reported by different investigators, using the same method of determination. As regards the effect of cooking, recent work has indicated that the most rapid loss of Vitamin C occurs during the first two minutes of cooking. Discarding the cooking water causes further considerable loss. Storage at low temperatures usually diminishes the rate of loss of Vitamin C, which may be very high at ordinary room temperatures.

The following selected list contains data for the Vitamin C status of certain fresh fruits and vegetables obtained in the open market at Columbus, Ohio. A modification of Tillman's method for determining Vitamin C was employed.

Vitamin C Content of Fresh Fruits and Vegetables.

Material	Variety	Source	Milligrams of ascorbic acid per gram fresh weight
Avocado	Unknown	Market	0.279
Banana	Unknown	Market	0.284
Cabbage	Average for 30 varieties	Garden fresh	1.002
Carrot	Tendersweet	do.	0.111
Cauliflower	Primosnow	do.	0.960
Chives	Unknown	do.	0.543
Cucumber	Chinese	do.	0.107
Egg Plant	Black King	do.	0.121
Grapefruit	Unknown	Market	0.364
Lettuce	Tennis Ball	Garden fresh	0.553
Lima Bean	Hopi	do.	0.296
Lime	Unknown	Market	0.398
Melon	Honeydew	do.	0.942
Okra	Long Green	Garden fresh	0.147
Onion	Brown	Mature	0.144
Orange	Navel	Market	0.480
Papaw	Wild	Freshly picked	0.360
Pea	Little Marvel	Garden fresh	1.028
Pepper (hot)	Hungarian Wax	Market	1.272
Potato, Irish	Early Ohio	Market	0.282
Soy Bean (green)	Jogun	Freshly shelled	0.428
Squash	White Bush	Market	0.232
Sweet Potato	Jersey	do.	0.326
Tangerine	Unknown	do.	0.484
Tomato (ripe)	Master Marglobe	Garden fresh	0.558

Some Effects Produced on Sugar-cane by Minor Elements.

It has been pointed out by R. J. Borden, (*Hawaiian Planters' Record*, Vol. XLIV (1940), No. 1, pp. 7-10), that while it is well known that the growth and yield of plants depends on liberal supplies of nitrogen, phosphate and potash in the soil, it is also known or strongly suspected that other elements are needed, though in comparatively small amounts; there is much data to show that growth failure may be traceable to a deficiency of one or other of these "minor" elements. The exact rôle of these minor elements, singly or in combination, still awaits clarification. As a contribution to the subject, the author made a pot experiment with 23 soils from different sources. Portions of each soil were given liberal applications of nitrogen, phosphate and potash, and in addition, some portions were given treatment with what is called an "A to Z ixture" which contains all the minor elements that are supposed to be of importance.

The composition of this A to Z mixture was as follows: Calcium sulphate, 41.25 parts; ferrous sulphate, 12.50; copper oxide, 4.50; copper sulphate, 0.50; boric acid, 2.50; zinc oxide, 2.25; zinc sulphate, 0.25; manganese dioxide, 5.00; manganous sulphate, 1.25; magnesium sulphate, 5.00; magnesium silicate, 25.00.

When the crops were harvested and analysed, a somewhat mixed picture was obtained. The presence of the minor elements produced quite different results on different soils. In some cases there was a significant increase of yield, and in others a significant decrease. The chemical composition of the juices was also variable. Evidently there is still much mystery in the relation of the minor elements to sugar-cane.—(*Facts about Sugar*, Vol. XXXV, No. 7, p. 34, 1940.)

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Organic and Inorganic Fertilizers; their Relative Effectiveness. *E. John Russell. Scottish J. Agr.* 22, 319-31 (1939).

There is no definite evidence that farmyard manure and other organic fertilizers are superior to equivalent quantities of inorganic fertilizers in increasing the yields and improving the quality of crops. Farmyard manure and composts are of particular value in supplying humus to the soil and improving its physical properties.—(*Chemical Abstracts*, 1940, Vol. XXXIV, p. 1800.)

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Copper Sulphate as a Soil Amendment on Truck Crops, and also on Cotton and Tobacco.

Copper sulphate added to fertilizers at the rate of 50 lb. ton increased the value of sweet potatoes, tomatoes and lima beans 4.47, 9.65 and 43.55 per cent. respectively. Copper sulphate increased the value of tobacco 33.85 per cent. 18.4 per cent. of this was due to increased yields and 15.45 to increased quality. Average yield of cotton was increased 20-23 per cent.—(*Imp. Bur. Soil Sci.*, List No. 77, p. 21.)